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R544 R551 R557 R562 R622 R624 R638 R646

(56) Documents cited

None

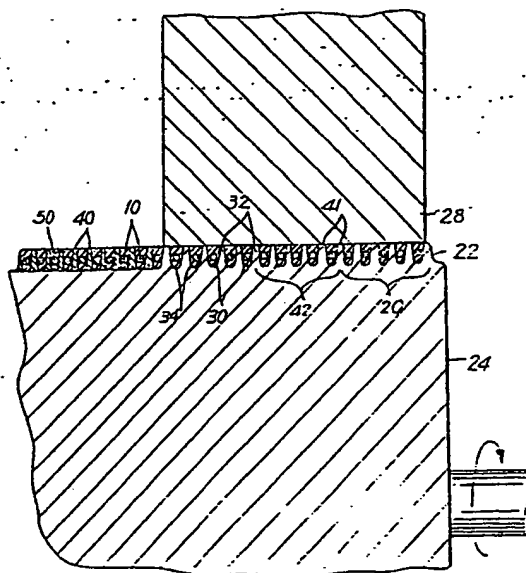
(58) Field of search

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(54) Nonwoven fabric

(57) In the production of a nonwoven fabric, for example for use as or in a papermakers fabric, an array of sheath core yarns of which the core has a higher melting point than the sheath, is fed in spaced parallel disposition to peripheral grooves (34) of a pinned roller (24) arranged in nip forming relationship with a press roll (28). The material of the sheath is melted as the yarns move into and through the roller nip and excess melted sheath material is forced into lateral grooves in the roller (34) to form structural members (40) between adjacent yarns (10). A wide belt may be formed by joining the strip (20, Fig 1) as it is formed to an earlier formed length of the strip.

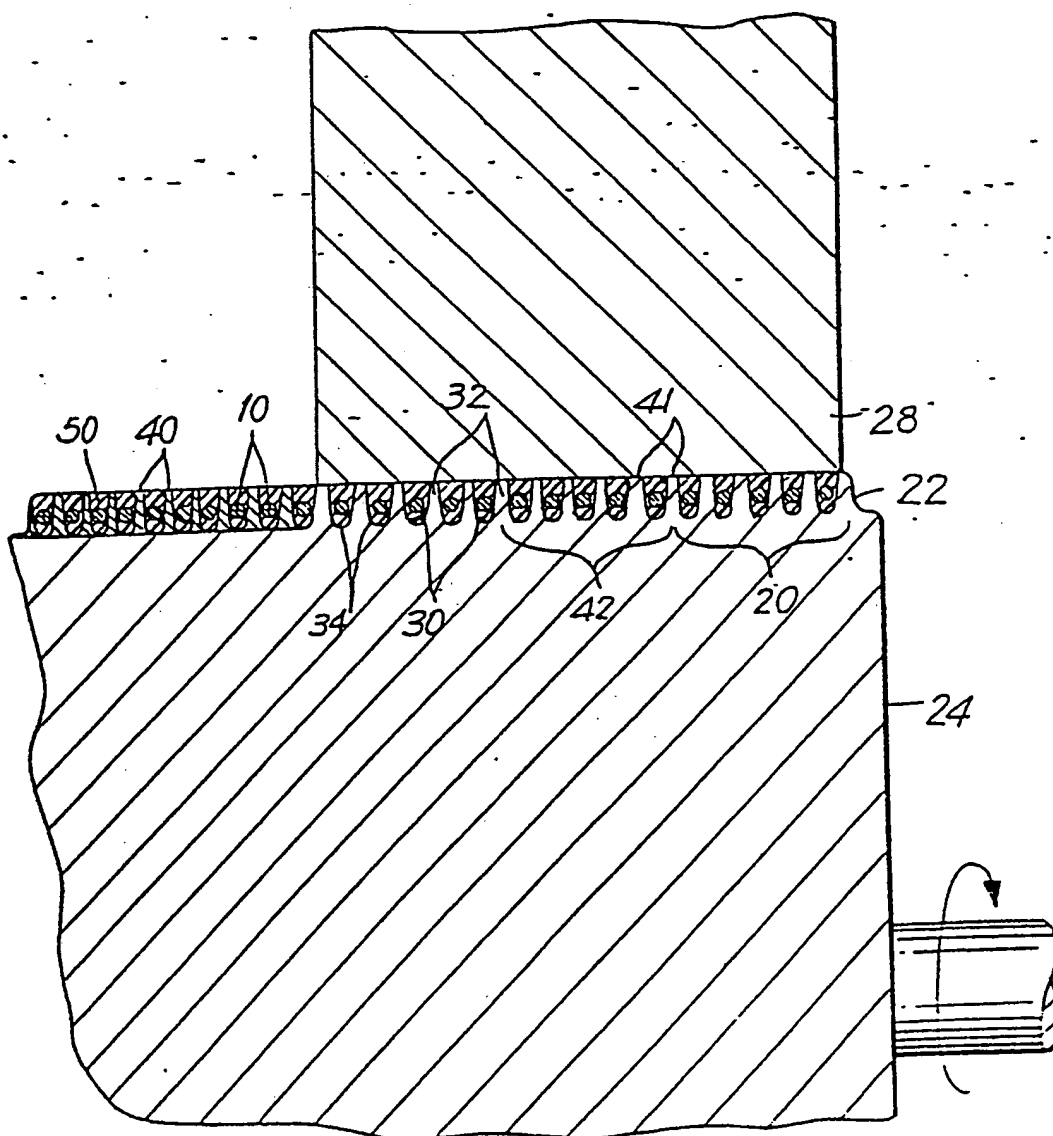
FIG. 3





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FIG. 3



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FIG. 4

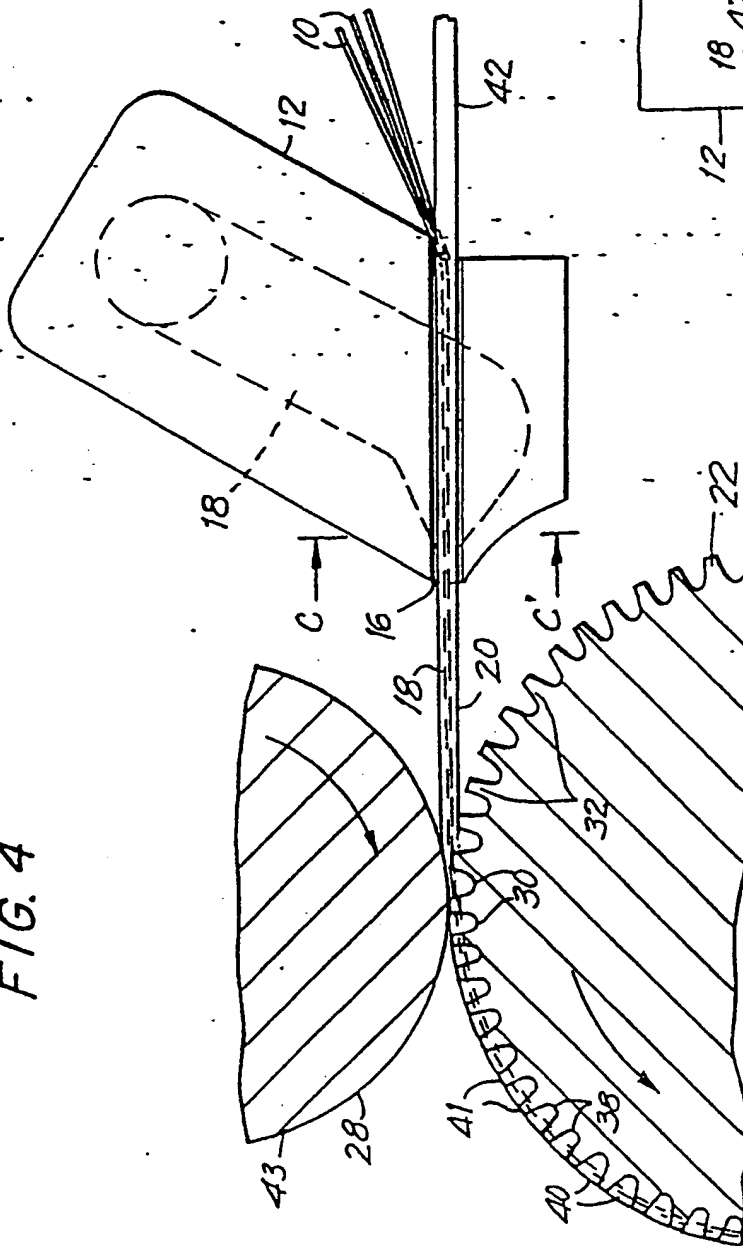
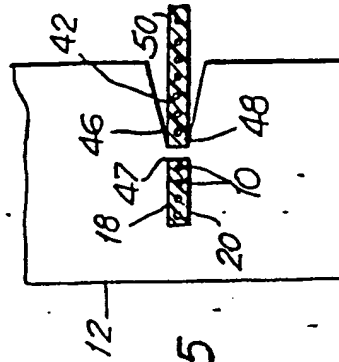
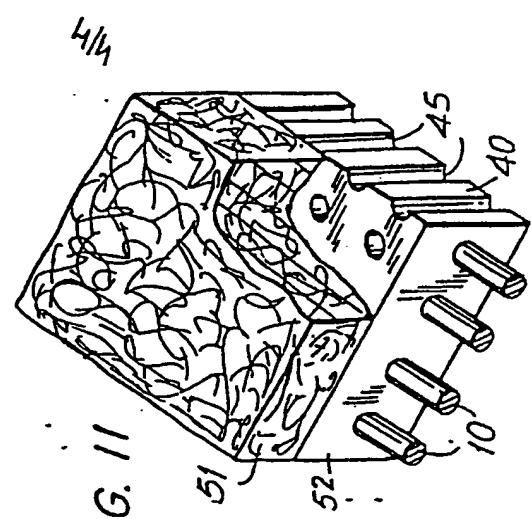
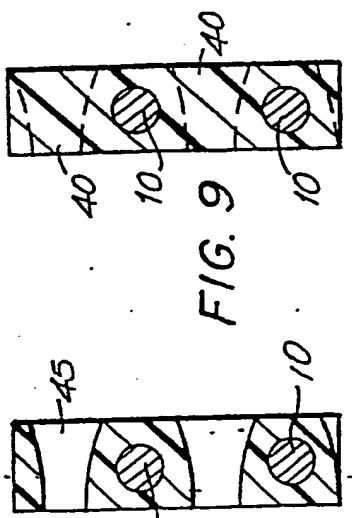
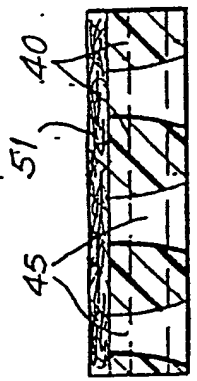
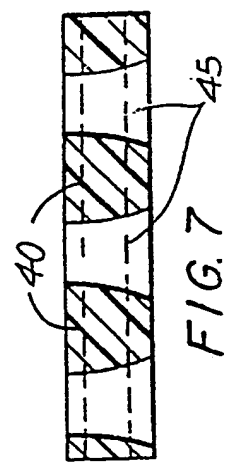
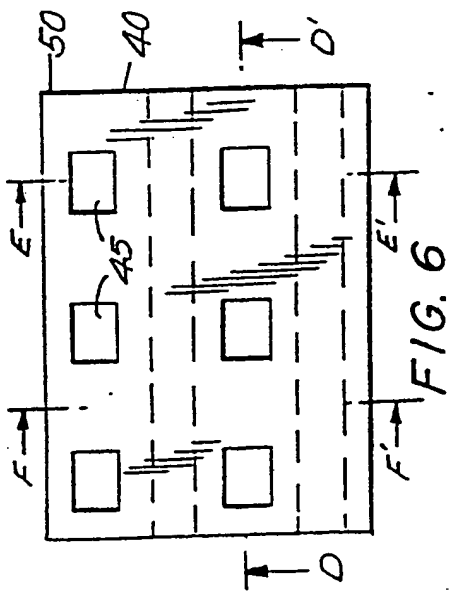


FIG. 5





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-1-

#### NONWOVEN FABRIC AND METHOD OF MANUFACTURE

This invention relates to a nonwoven fabric and has particular, though not exclusive, reference to nonwoven paper machine forming fabrics, felts and dryer fabrics and 5 a method for the manufacture thereof.

For many years weaving has been the principal method of constructing fabrics for use on paper machines. In the case of papermaker felts, some success has been achieved with needle punched nonwoven felts of the "fillingless" 10 type. See, for example, U.S. Patent No. 3,392,079, incorporated herein by reference. Such felts are made by winding spaced apart parallel machine direction yarns around tension rollers, covering the yarns with fibre batt, and needling the batt into the yarns from both sides to 15 form a consolidated nonwoven felt.

Under low press loadings such fillingless felts operate satisfactorily; however, under high press loadings fillingless felts are not satisfactory because the machine direction yarns leave undesirable indentations in the paper 20 sheet. Furthermore, such fillingless felts are prone to widening during operation on the paper machine. Thus, such felts are seldom used on highly loaded presses.

Although nonwoven felts are known, it has not been hitherto possible to make paper machine forming fabrics 25 without weaving. A satisfactory forming fabric made by needling batt fibres into a parallel array of yarns in the

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-2-

same manner as fillingless felts is not practical, because such a product would lack sufficient surface uniformity and drainage, would tend to fill up with fines, and would interfere with release of the sheet after formation.

5 Nevertheless, the concept of producing a forming fabric without weaving, has been the subject of continuing interest due to the high cost of manufacturing woven forming fabrics by present methods.

10 In the case of paper machine forming fabrics, present trends are toward multi-layer woven fabrics having coarse woven substrates made of thick yarns in the wear side of the fabric, with small yarns woven in fine mesh in the sheet forming side of the fabric. The coarse yarns are used to impart wear resistance to the fabric, while the  
15 fine mesh surface is used to achieve good sheet formation. It has not been possible to make a woven forming fabric with a smooth sheet forming surface using the same coarse yarns needed to achieve the desired wear properties. The multi-layer fabrics, while providing both smooth surfaces  
20 and good wear properties, are difficult and time-consuming to manufacture due to their structural complexity.

Nonwoven fabrics and the manufacture thereof are well known. For example, U.S. Patents Nos. 4,259,399 and 4,285,748, both of which are incorporated herein by  
25 reference, disclose the preparation of nonwoven fabrics. However, fabrics proposed therein are not suitable for the

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-3-

applications contemplated here.

With regard to papermakers felts having porous incompressible woven substrates capped with porous fibre layers, known as batt on mesh felts, such felts require 5 sufficient batting to reduce the extremes of pressure that would otherwise occur over fabric knuckles or weave crossovers. This is necessary since otherwise uneven pressure would reduce press dewatering efficiency and might have an adverse effect upon sheet quality.

10 When prior art woven felts are made with incompressible monofilaments, such base fabrics invariably contain interconnected water flow passageways between yarns. Such passageways allow water to flow forward in the machine direction through the felt base fabric while the 15 felt and paper sheet are subjected to hydraulic and mechanical pressure in the press nip. Such transverse water flow forward in the nip may contribute to increased sheet moisture and reduced pressing efficiency.

Transverse passageways in the woven base fabric also 20 provide channels for the entry of air into the expanding sheet and felt as they leave the press nip. It is suspected that such air entry into the incompressible woven felt substrate may facilitate water transfer from within the sheet-felt interface back into the expanding paper 25 sheet as it emerges from the press nip, thereby reducing press efficiency.



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-4-

In the manufacture of filtration fabric belts for sludge concentration, as well as other purposes, it is often desired to produce a fabric having many small openings, made from yarns that are large enough to provide 5 long service life. Where such yarns are thick monofilaments, they are difficult to weave close enough together to provide the fine mesh openings desired. A compromise is often necessary, the compromise involving a trade-off to smaller yarns so that the desired mesh can be 10 woven.

A nonwoven paper machine dryer fabric comprised of plastic monofilament spirals is also known. Each spiral is joined to its neighbour by means of a pin inserted through the intermeshed loops of the adjoining spiral to form an 15 endless porous dryer fabric belt. As a result of this joining method, such belts are susceptible to failure should any one of the thousands of spiral connecting pins fail during operation on the paper machine.

Porous plastic sheets are known wherein holes are 20 created in the plastic sheet during formation, such as by extrusion of two sets of filaments at right angles to each other which are fused together at crossover points. Such sheets are comprised of unoriented polymer material, and if produced in the fineness needed for papermaking 25 applications, they would lack sufficient dimensional stability to operate as endless belts on paper machines.

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-5-

This type of material may be subjected to stretching to orient the filaments to achieve increased stability, but at the price of causing the spaces between members to increase beyond the fineness needed for certain applications.

5        Dimensionally stable plastic sheet material may be rendered porous by means of perforating, drilling or the like; however, such fabrication methods preclude the use of combinations of materials that are particularly suited for specific tasks. For example, machine direction stretch  
10 resistance may best be satisfied with high modulus materials, whereas, cross-machine direction needs may call for materials that are resilient and of lower stiffness.

It is an object of the invention to provide dimensionally stable nonwoven fabrics for paper machines as  
15 well as other uses having machine direction reinforcing members and smooth surfaces.

It is also an object of the invention to provide fabric for paper machines and other uses with essentially no vertical or horizontal crimp, and with machine direction  
20 and cross-machine direction members lying substantially entirely in the same plane.

It is a further object of the invention to provide nonwoven felts for papermaking and other uses wherein the non-deformable base fabric layer contains respective fluid  
25 flow passageways perpendicular to the plane of the fabric.

It is a yet further object of the invention to provide

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-6-

felts or forming fabrics having fine fibre or foam sheet contact surfaces integrally bound to a nonwoven base fabric.

It is a still further object of the invention to  
5 provide nonwoven fabrics for papermaking as well as for other purposes having high modulus load bearing reinforcing elements disposed in the machine direction and substantially entirely encapsulated by porous polymeric matrix material characterised as having resistance to  
10 abrasive, chemical, or heat degradation.

It is additionally an object of the invention to provide nonwoven fabrics wherein cross-machine direction polymeric matrix material may be selected from a wide range of materials, including at least some materials which are  
15 not formable into textile yarns.

According to the present invention there is proposed a method of producing a nonwoven fabric comprising the steps of providing an array of spaced parallel yarns, each said yarn having a polymeric sheath thereto, heating the array  
20 to melt the said polymeric material, constraining subsequent flow movement of the said material to predetermined paths extending between and joining adjacent such yarns to form a matrix, and thereafter cooling the polymeric material of said matrix to effect setting  
25 thereof.

Forming fabrics for paper machines operate at high

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-7-

speeds while under substantial machine direction (i.e., the direction in which the fabric runs) tension. In fact, some machine positions are so sensitive to stretch that even a one percent extension may result in the need to remove the fabric from operation on the machine. In the case of woven forming fabrics, such fabrics are subject to extension by two mechanisms; machine direction yarn stretch and machine direction yarn straightening through crimp interchange. In U.S. Patent No. 3,858,623, incorporated herein by reference, a woven fabric construction is taught which avoids stretch due to crimp interchange.

In the fabric of this invention there is no crimp imparted to the machine direction yarns because they are not interlaced with a second system of yarns as in woven fabric. Rather, the machine direction yarns lie perfectly straight within the surrounding and substantially encapsulating polymeric matrix material. Demand for cross-machine direction stability may readily be met by the matrix material, even though it is not oriented, as are the high modulus machine direction yarns. Cross-machine direction loads are only a small fraction of machine direction loads. More important is the ability of the matrix material to provide the necessary long lasting wear surfaces needed for competitive performance in this application.

The matrix material may be selected from a wide

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-8-

variety of polymeric materials without regard for their ability to be formed into fibres or yarns. One of the best materials in terms of wear resistance is polyurethane. Even though this material is not available in usable yarn  
5 form, it could be used for the matrix material of fabrics of this invention intended for the forming fabric application. Other useful materials include polyesters, such as polyethylene terephthalate, polyamides, such as nylon, specifically nylon 6, nylon 6,6, or nylon 12, and  
10 polyethylene. The matrix material preferably has a melting temperature lower than that of the yarn employed.

In the case of felts for papermaking and like purposes, the porous matrix layer is comprised of non-deformable polymeric material. By non-deformable it is  
15 meant that any deformation that may take place during passage of the felt through the paper machine press nip would be minimal such that fluid passageways contained within the non-deformable matrix layer would remain open, thereby continuing to provide void space for the  
20 accommodation of fluid even under high pressure loading conditions.

The preferred papermaking felt of this invention would have a sheet contacting surface layer comprised of porous resilient fibres or foam attached to the base layer by  
25 fusion bonding or the like. Preferably, the fibrous surface layer would be mechanically interlaced as, for

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-9-

example, by needling prior to attachment to the base. This would give batt fibres some vertical alignment and would impart physical integrity to the batt prior to attachment. It would also ensure that fibres from the top of the batt 5 as well as those from the bottom of the batt would become adhered to or embedded within the non-deformable matrix material of the base layer. . . .

Where fabrics of the invention are intended for geotextile or filtration applications, porous fibres or 10 foam may optionally be added to one or both sides of the yarn containing matrix material. In the alternative, they may be positioned throughout the matrix material itself, according to the application requirements.

In the case of nonwoven fabrics of the invention 15 intended for the paper machine dryer section, machine direction tension bearing members may preferably be selected from among those materials noted for their hydrolytic stability and resistance to heat degradation. Materials such as Nomex or Kevlar (polymeric materials 20 available from DuPont) may be considered, even though such materials are available only in spun or filament yarn form and would ordinarily wear out rapidly in woven dryer fabric structures. By encapsulating such yarns within the matrix material, they can be protected from abrasive wear 25 and exposure to steam which otherwise would significantly reduce their service life. . . .

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-10-

Present dryer fabrics often use polyester monofilaments, despite their susceptibility to damage by hydrolysis. By encapsulation of polyester yarns within the matrix material according to the invention, such yarns  
5 would be protected from steam exposure, thereby preserving yarn strength better than in woven or spiral mesh nonwoven dryer fabrics.

In the case of dryer fabrics, the matrix material itself may be selected from among the entire spectrum of  
10 flexible polymeric compounds without regard to yarn forming ability of the material. Whereas conventional woven or spiral mesh dryer fabrics are comprised of textile yarns with the possible addition of resin treatments, the dryer fabric of this invention may utilize a non-fibre forming  
15 matrix material if this would provide better service life or afford manufacturing or material economies. For example, silicone rubber may prove to be an ideal matrix material even though it is not presently available in yarn form for use in woven dryer fabrics.

20 Fabrics of this invention may be produced in either endless belt form or in flat form. Also, fabrics may be readily produced by use of a machine direction yarn of a material which possesses a melting temperature higher than that of the polymeric matrix material.

25 In other cases the matrix material may be a thermosetting plastic material, or it may be a resinous

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-11-

material which is water-reactive. In still other cases, the matrix material may be a reaction molding compound which polymerizes almost immediately after being mixed together.

5       The invention will now be described further, by way of example, with reference to the accompanying drawings in which:-

Fig. 1 is a plan view of an apparatus suitable for use in practising the invention;

10      Fig. 2 is a lateral cross-sectional view taken along line A--A' of Fig. 1;

Fig. 3 is a partial, front, cross-sectional view taken on line B--B' of Fig. 1;

Fig. 4 shows a part of Fig. 2 drawn to a larger scale;

15      Fig. 5 is a cross-sectional view taken on line C--C' of Fig. 4;

Fig. 6 is a plan view of a portion of a fabric constructed in accordance with the invention;

Fig. 7 is a cross-section through the fabric of the 20 invention taken in the machine direction and on line D--D' of Fig. 6;

Fig. 8 is a cross-section through a fabric made in accordance with the invention taken in the cross-machine direction and on line E--E' of Fig. 6;

25      Fig. 9 is a cross-section through the fabric in the cross-machine direction and taken on line F--F' of Fig. 6;



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-12-

Fig. 10 is a view corresponding to Fig. 7 and shows a variant of the fabric having a layer of fibre batt adhered to its top surface; and

Fig. 11 is a perspective view of the fabric of Fig. 10 with a portion of the fibre batt removed for added clarity.

Referring now to the drawings, and particularly to Figs. 1, 2 and 4, an array of monofilament, multifilament, or spun yarns 10 is fed into extruder die 12 attached to extruder 14, which is filled with matrix material 18. - 10 Yarns 10 are pre-tensioned to provide better control. The extruder die outlet 16 is shaped to produce a ribbon-like tape having a side-by-side array of parallel yarns 10 encapsulated within molten plastic matrix material 18. This can be seen more clearly in Fig. 5.

15 As illustrated in Figs. 1 and 4, newly formed tape 20 is immediately fed into pinned section 22 of drive roll 24 while the plastic matrix material 18 is still in a melted state. Drive roll 24 is driven by variable speed motor 26 at a speed to accommodate the output flow of extruder 14.

20 Immediately subsequent to contact with the pinned section 22, the newly formed tape is subjected to conditions of heat and pressure by heat press roll 28, thereby forcing the still soft extrudate into the grooves 30 between pins 32 of pinned section 22. Yarns within the 25 tape are guided into engagement with machine direction grooves 34, where they are surrounded and encapsulated by

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-13-

solidifying plastic matrix material. Plastic matrix material is likewise forced into cross-direction grooves 38, to form cross-direction interconnecting structural members 40.

5        Top-most pin extremities 41 contact the outer surface 43 of heated roller 28. This forces plastic material from between these mating surfaces and causes holes 45 to be formed at each such contact point.

For flat fabric, pinned section 22 extends fully 10 across the drive roll 24, so that the desired fabric width can be produced in a single pass. In such a case the material continues around the pinned roll until it cools sufficiently for complete solidification to occur whereupon it is pulled off the pinned roll by a fabric windup device.

15 Flat formed fabric thus produced may subsequently be formed into endless belts by conventional joining methods.

To produce wide endless fabrics suitable for purposes such as paper machine clothing without need for a subsequent jointing step, it is necessary to make repeated 20 passes onto the pinned section 22 as shown in the drawings.

In such endless fabric production, the newly formed tape continues halfway around the pinned section 22 while it solidifies into hardened tape material 42. The hardened tape travels around tail roll 44 and is then returned to a 25 position on pinned section 22 immediately adjacent to the next successive wind of newly forming tape 20.

(18397A)  
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-14-

It should be understood that newly forming tape 20 and hardened return run tape 42 are actually successive portions of the same continuous tape. However, for purposes of clarification, they are referred to as if they were separate entities.

Prior to re-entering pinned section 22, return-run tape-edge 48 adjacent to newly forming tape 20, is brought into intimate contact with the slotted outer surface 46 of extruder die 12 so that it is softened and fuses, in butting relationship, into adjacent melted edge 47 of newly forming tape 20. Both the return-run tape 42 and the newly formed tape 20 are then fed side-by-side adjacent to each other onto pinned section 22, where they are subjected to heat and pressure by press roll 28, thereby improving the bonding between the two tapes. Through this means, newly formed tape 20 is continuously joined to previously formed and hardened tape 42 into an endless porous belt 50 comprised of side-by-side tapes whose boundaries are barely discernible.

In an alternative arrangement, not illustrated, the edge regions of the newly formed tape, or indeed the tape as a whole, are of multi-stepped configuration, such that the newly formed tape 20 and return-run tape 42 form an overlapping, rather than a butt, joint, the extruder die 12, pinned section 22 and press roll 28 being profiled, and the guiding of tapes 20 and 42 in the region of the

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-15-

extrusion die being modified, accordingly.

It may be found convenient, in some instances, to include further yarns at intervals transversely of the tape 20, such yarns extending from the longitudinal edges of the tape and being embedded in the adjacent edge of the return-run tape on bonding together of the two tapes.

The thickness of the machine and cross-machine direction members created by this method need not be the same. It is desirable in most cases that the yarn be fully encapsulated. It should be understood, however, that many variations in pin shape and spacing may be utilized to achieve particular construction objectives, dependent upon the end use application of the flat fabric or endless belt being produced.

For geotextile or filtration applications, fabrics of this invention may be further enhanced by the addition of a layer of porous membrane, open cell foam, fibrous matt, fibres, or the like to one or both sides of the yarn-containing matrix material. Alternatively, foam or fibres may be positioned throughout the matrix material itself. In the papermaking field, for example, a fine pore-size open-cell foam may be added to the sheet-contacting surface of the fabric, to render the fabric suitable for use as a wet press felt.

In some cases, the surface of heated top roll may be embossed to impart a particular surface pattern to

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-16-

the fabric as it is formed.

It should be noted that the fabric of this invention differs from conventional woven fabrics in several respects. In particular, the requirement of woven fabrics that machine direction yarns pass over or under cross-machine direction yarns does not apply to the fabrics of this invention. As can be seen from Figs. 7 to 11, the matrix material encapsulating machine direction yarns lies in the same plane and interconnects with cross-machine direction matrix material. With this type of construction, the homogeneous combination of matrix materials in machine and cross-machine directions can provide independent non-interconnected void spaces between yarn elements. This factor may have special significance when the fabric is employed as a wet press felt for papermaking.

Fig. 6 shows a plan view of a fabric produced by the method aforesaid, from which it can be seen that the fabric is in actuality a porous, reinforced plastic composite wherein machine direction yarns are the reinforcement elements and the surrounding matrix material contains fluid passageways, fully encapsulates the yarns, and joins yarn to yarn to make the nonwoven fabric of the invention.

In Figs. 10 and 11, a fibrous surface layer 51 is shown integrally bound to matrix material 52. In the preferred case, such bonding is accomplished by pressing the heated fibrous layer 51 down into the lower melting

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-17-

temperature matrix material while partially melting this material, thereby allowing the batt fibres to become firmly embedded within the matrix material.

In the discussion above, the problem of water flow in the press nip was addressed. It is thought that fabrics produced as aforesaid will provide substantially more flow control than present felts. Water, having flowed through a fine porous sheet contact layer, may only pass vertically into the void spaces between machine direction and cross-direction fabric members since such void spaces are not interconnected but, rather, are surrounded by matrix material which forms effective barriers to the transmission of water in the transverse plane, and in particular, in the machine direction.

15 In the method of the present invention the fabric is made entirely from sheath-core yarns having a core comprised of non-melting or high temperature melting monofilament or multifilament yarn and a sheath comprised of lower melting temperature fusible material. For 20 example, the yarn core may be a high modulus nylon 6,6 multifilament and the yarn sheath may be nylon 12 material.

An array of side by side sheath-core yarns is fed into the machine direction grooves 34 of pinned roll section 22, thereat to be forced down into the grooves by heat and 25 pressure by press roll 28. The sheath core monofilament cross section area is greater than the area of machine

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-18-

direction groove 34, so that excess melted sheath material is forced into cross direction grooves 38 to form the cross directional interconnecting structural members 40.

The invention is not limited to the exact features as 5 hereinbefore disclosed, since alternatives will readily present themselves to one skilled in the art.

Attention is drawn to my copending Patent Application -No. 8807416, from which this application is divided and which has claims directed to a nonwoven fabric and to a 10 method for the manufacture thereof as described and illustrated herein.

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-19-

#### Claims

1. The method of producing a nonwoven fabric comprising the steps of providing an array of spaced parallel yarns, each said yarn having a polymeric sheath thereto, heating  
5 the array to melt the said polymeric material, constraining subsequent flow movement of the said material to predetermined paths extending between and joining adjacent such yarns to form a matrix, and thereafter cooling the polymeric material of said matrix to effect setting  
10 thereof.

2. The method as claimed in claim 1, wherein the flow movement of the polymeric material is constrained to individual paths arranged in spaced apart disposition in the longitudinal direction of the said yarns.

15 3. The method as claimed in claim 1 or 2, including the further steps of presenting the set yarn/matrix structure in edge-to-edge relationship with a further array of sheathed yarns, heating the further array to melt the polymeric material thereof, constraining subsequent flow  
20 movement of the polymeric material of the yarns of the further array to predetermined paths extending between and joining adjacent such yarns and extending between the yarns of said further array and into adhering relationship with the edge of the said set yarn/matrix structure, and  
25 thereafter cooling the polymeric material.

4. A nonwoven fabric comprising a plurality of spaced



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-20-

parallel yarns encapsulated within a polymeric material matrix, manufactured in accordance with the method claimed in any one of the preceding claims.

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